Interactive Hand Sensor User Manual

https://interactive-hand-sensor.com/root/

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1. important matters

1. Safety
    a. If you notice any abnormalities such as odors or smoke during operation, or if the product does not operate properly, turn off the power immediately and check.
    b. Do not touch the main board and sensor board during operation.
    This is because there is a risk of damage or malfunction due to static electricity.

2. Effect on nearby remote control devices
    a. Since it continues to emit strong infrared rays during operation, it may affect nearby infrared remote controls (air conditioners, home appliances, etc.).
    b. If the remote control does not work, please change the angle and location.

3. Sensor sensitivity adjustment
    a. The sensitivity of the 8 sensors has been adjusted at the time of shipment, but it may deviate due to vibration or other factors. as neededPlease adjust the sensitivity.

2. Features

2-1.Photoreflector type three-dimensional space sensor

1. principle
    a. Infrared LED (ILED) to instantaneously pass a large current through the phototransistor (PhTr)
    b. The reflected light is converted into voltage and read with a 12bit AD converter. (Principle diagram)
    c. the sensorX, Y directionto detect hand movements in 3D.
2. Z directionThe detection distance is 20 cm or more, and if it is exposed to strong light, false detection and decreased sensitivity will occur.
3. Z directiondistance measurement accuracy is low. High-speed, high-accuracy detection is possible in the X and Y directions.
4. Uses ordinary infrared LEDs and does not use harmful light such as lasers and ultraviolet rays.
5. Software corrects for noise and sensor variations to improve accuracy.

2-2. Color LED (CLED)

1. It is set by the microcomputer independently of the sensor. (Can also be linked with a sensor)
2. You can control the light intensity with PWM.

2-3.Application example

Main board Parallel connection : Operation confirmed up to 16 sheets

Sensor board extension cable: The sensor can be placed anywhere (such as a model)

2-4.Electrical specifications

project	content	remarks
Power-supply voltage	5V	Assuming USB power supply
controller voltage	5V, 3.3V	Signal output 3.3V
consumption current	180mA (scan time 1.2mS)	Typical value for single board
power consumption	1W	Typical value for single board
Scan time board alone	1.2mS or more, 1 channel 150uS or more	
Scan time parallel continuation	800uS or more, 1 channel 100uS or more※	

※In order not to reduce the detection distance, it is desirable to use 150uS or more per channel.

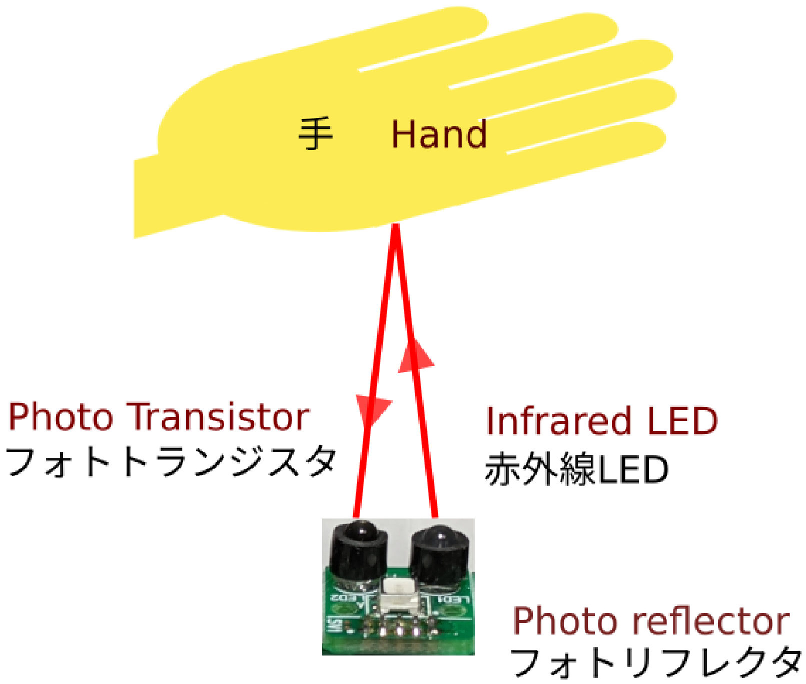


Figure 2-1. Photoreflector principle

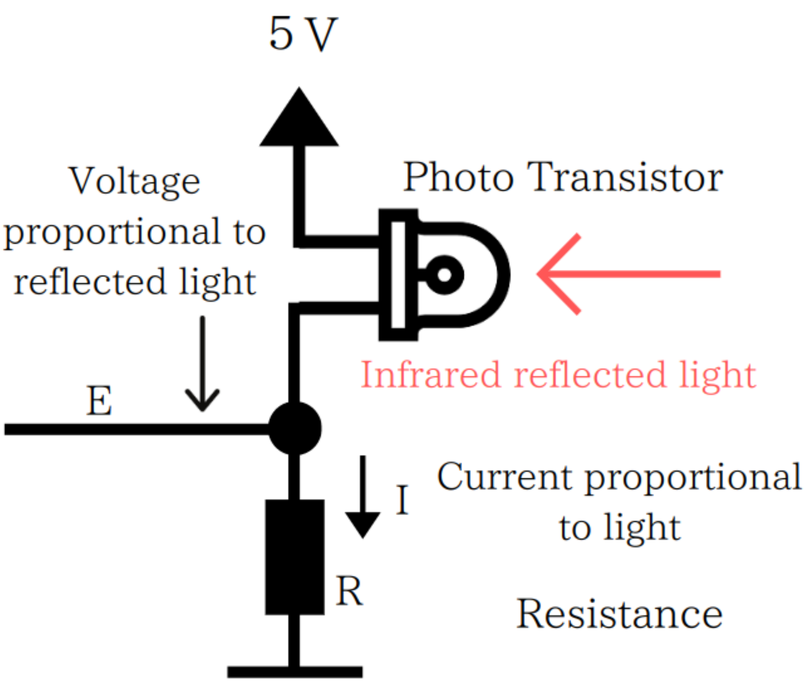


Figure 2-2. Mechanism of light-voltage conversion

1. Phototransistor converts light intensity into current I
2. Apply current I to resistor R and convert to voltage E
3. Read voltage E with 12bit AD converter

3. hardware

3-1.Main board

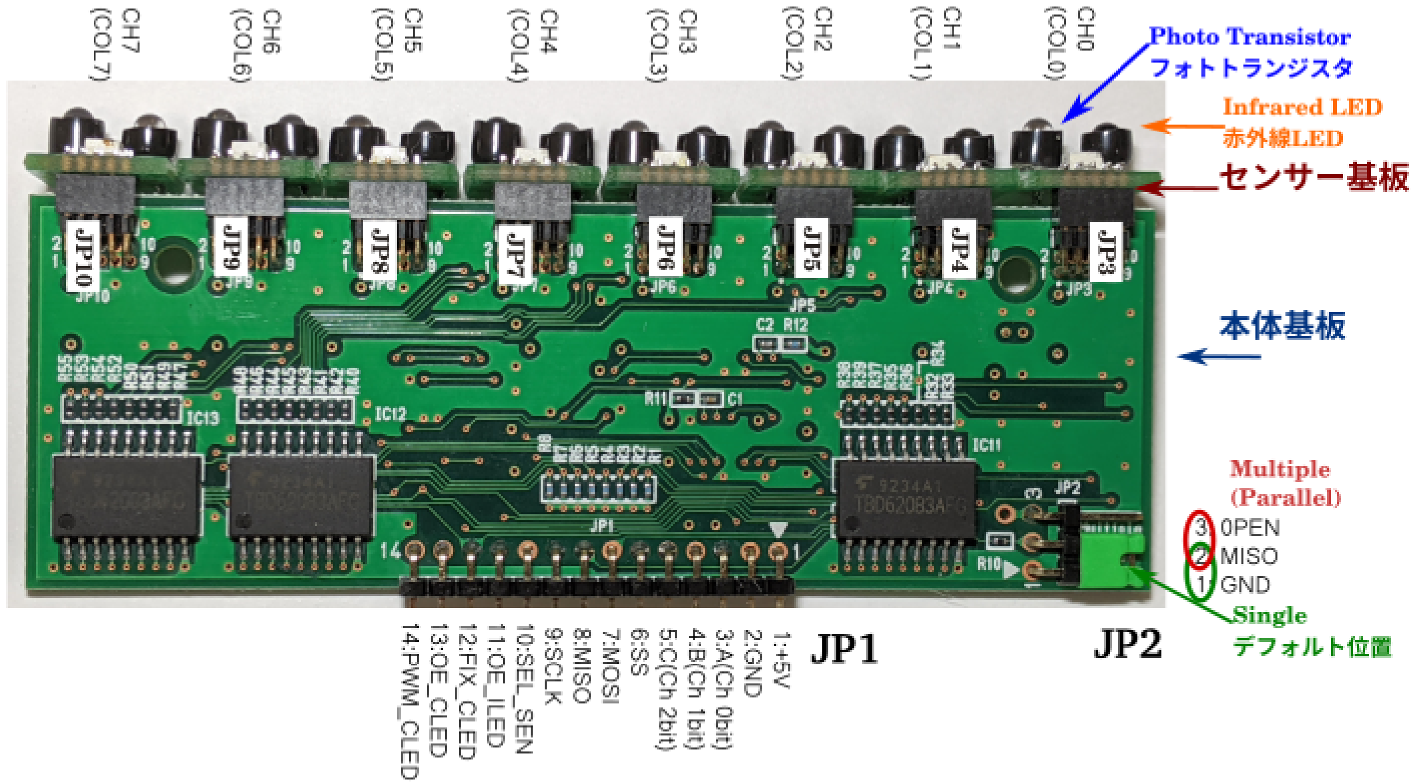


Figure 3-1. Main board

*The green board is the same pattern as the mass-produced board, but the 3 prototype boards with different colors are the same as the mass-produced product except for the color.
The photo will be changed to a black substrate in future revisions.

Major digital ICs (please refer to them for software development)

Model	reference number	PIN	explanation
MCP3208T-BI/SL 12bit AD converter	IC1	6,7,8,9,10	Phototransistor voltage detection, interface is SPI
74HC595 shift register	IC10,11,12	6,7,8,9,10, 12,13,14	Control CLED with serial-parallel conversion
74HC138 decoder	IC3	3,4,5	Select ILED channel (0-7)

3-2. Main board pinout (JP1)

pin number	PIN name	explanation
1	+5V	Vcc 5V
2	GND	GND
3	A	Sensor channel(0-7) 0bit
4	B	Sensor channel(0-7) 1bit
5	C	Sensor channel(0-7) 2bit
6	SS	SPI Slave-Select (active-Low) Substrate selection when connecting in parallel
7	MOSI	SPI Input
8	MISO	SPI Output (3.3V/5V switching JP2)
9	SCLK	SPI Clock
10	SEL_SEN	SPI selection High: Sensor (AD converter), Low: CLED
11	OE_ILED	ILED Output Enable ※ILED: Infrared LED ILED enable/disable * Infrared radiation is automatically performed in synchronization with the AD converter.
12	FIX_CLED	CLED Shift Register Latch ※CLED: color LED Reflect the value of the shift register to the output
13	OE_CLED	CLED Output Enable CLED output ON/OFF
14	PWM_CLED	Adjust the brightness of the CLED with PWM (Pulse Wide Modulation) control Short to 13pin or 5V when not using PWM

summary

- SEL_SEN pin for SPI switching of sensor (AD converter) and CLED.
- Set the ILED channel with ABC.
- After CLED transfers data to the shift register, it is reflected in the output with a FIX_CLED pulse.
- CLED ON can adjust the brightness with AND output of 13pin and 14pin and PWM of 14pin.

3-3.JP2 pinout

pin number	PIN name	explanation
1	GND	GND
2	MISO	For single/parallel connection selection
3	OPEN	OPEN

summary

- **Switch for countermeasures against SPI output (MISO) dropping during parallel connection**
- **When using the board alone, as it is (single)**

  Shorted PIN1-2 with a jumper pin, factory default.
- **When connecting in parallel, short PIN1-2 (single)、The rest are 2-3 short (multiple, OPEN)**

  The SPI output pin MISO divides the 5V signal by 1KΩ and 2.2kΩ to convert it to 3.3V. Countermeasure for lower signal level when boards are connected in parallel (due to lower combined resistance).

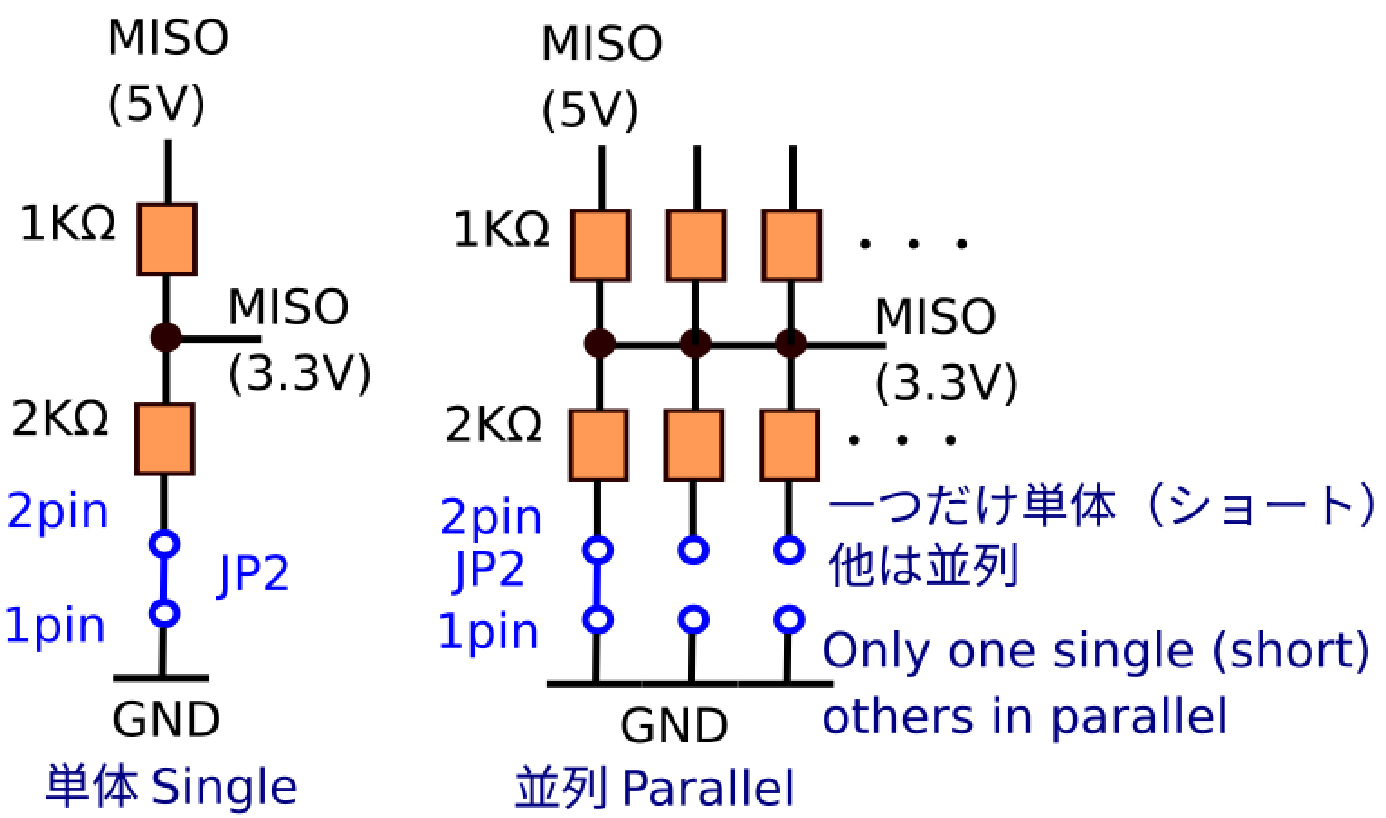


Figure 3-2. Description of JP2

3-4.Sensor board

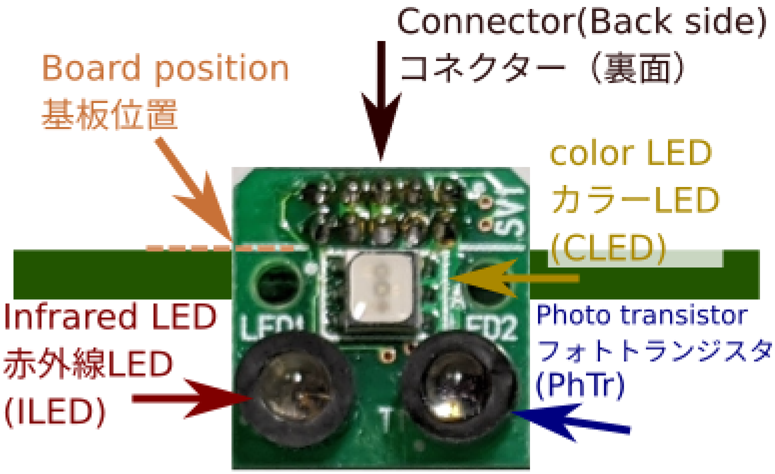


Figure 3-3. sensor board

- Check for pin misalignment before operation.
- Do not force the connector.
- It will generate heat during operation.

3-5. Attaching the sensor board 1: Main board

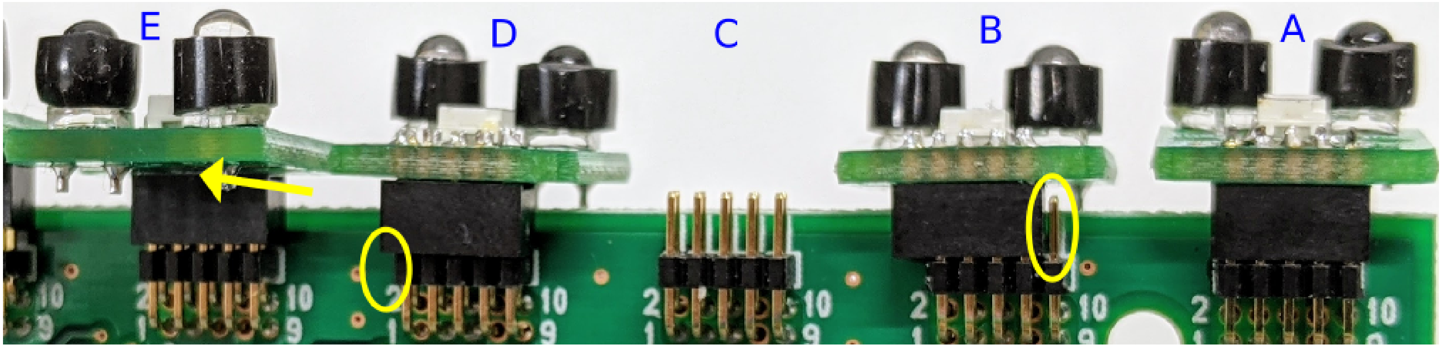


Figure 3-4. Good and bad examples of sensor installation

A: Good

B: 1 row lateral shift, bad

C: none, bad

D: 1 row ahead, bad

E: opposite direction, bad

- Do not connect or disconnect the sensor while the power is on.
- The pin layout is designed so that it is hard to break even if it is 1 row out of alignment or in the opposite direction, but if it does not light up, please turn off the power and fix it.

3-6. Sensor board installation 2: Ribbon cable

- Requires 2 ribbon cables, a pin header for polarity reversal, and a pin header for sensor mounting.
- Ribbon cable is 1.27mm pitch 10pin

※**When using one ribbon cable, the terminals are left-right reversed.**does not work because

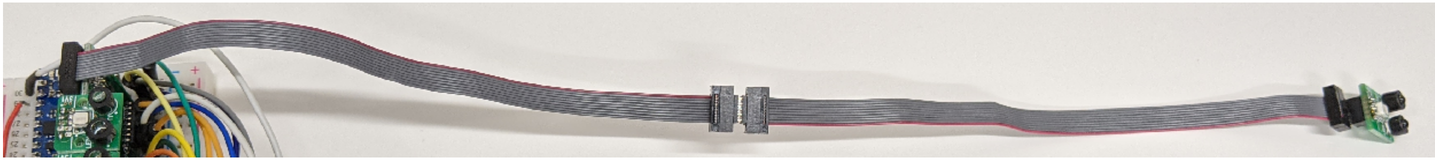
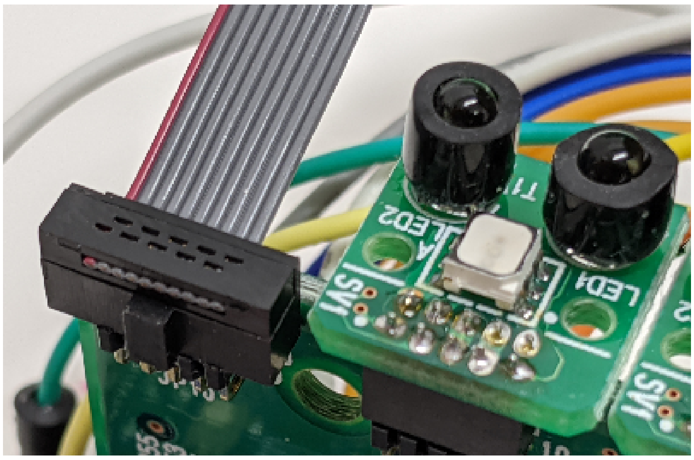


Figure 3-5. Overall view of ribbon cable



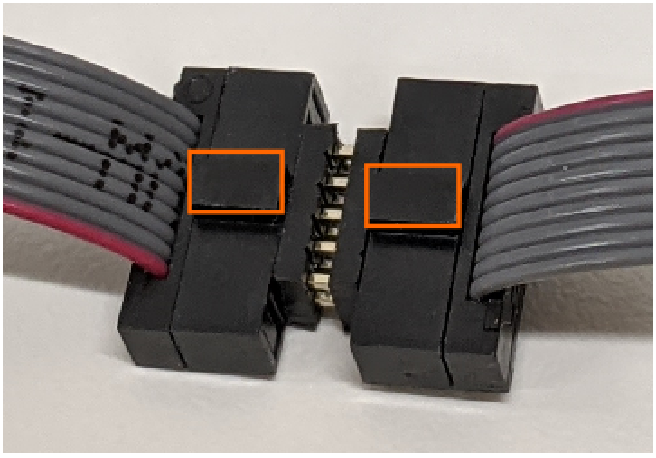
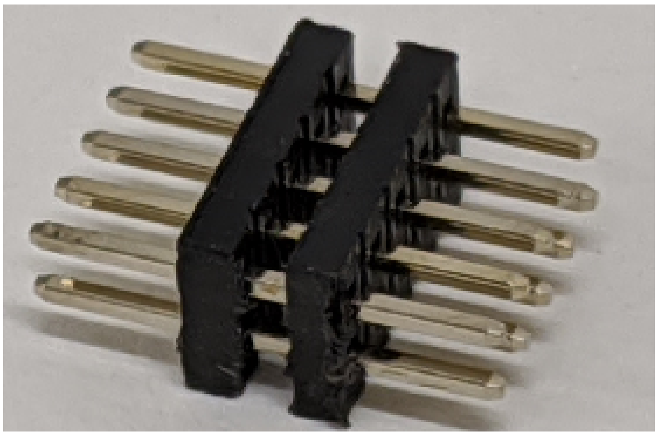


Figure 3-7. Attaching the ribbon cable main board Fig. 3-6. Ribbon cable junction



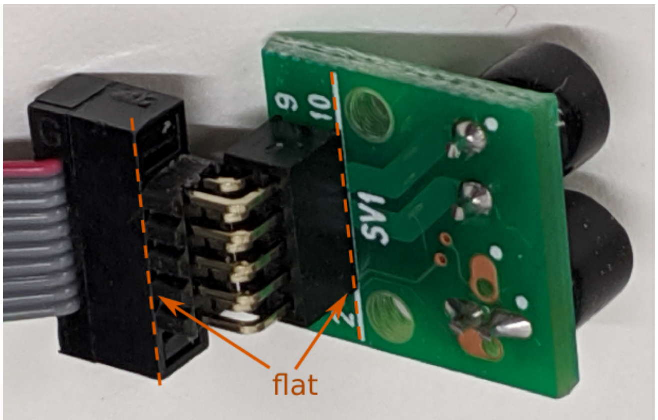


Figure 3-8. Pin header for polarity reversal 1.27 mm pitch Fig. 3-9. Ribbon cable sensor board installation

※The pin header for polarity reversal is 10-pin 1.27mm pitch, pin length 3mm

3-7. Sensor sensitivity adjustment method

ILEDandPhTrYou can adjust the sensitivity of the sensor by moving the black cover up and down, but please be careful as it may deviate from the optimum sensitivity. ※ILED: Infrared LED PhTr: Phototransistor

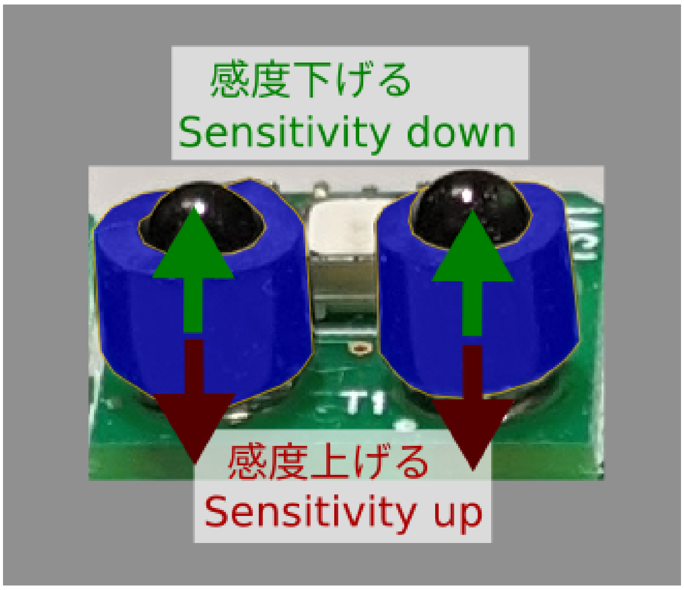


Figure 3-10. Sensitivity adjustment illustration

Increase sensitivity: (Increase the exposure of ILED, PhTr and easily receive light)

1. Lower the PhTr black cover.
2. Lower the ILED black cover.
3. If the black cover is too high and cannot be lowered, cut the black cover as shown below.

Priority is in the order of A and B in the figure below.

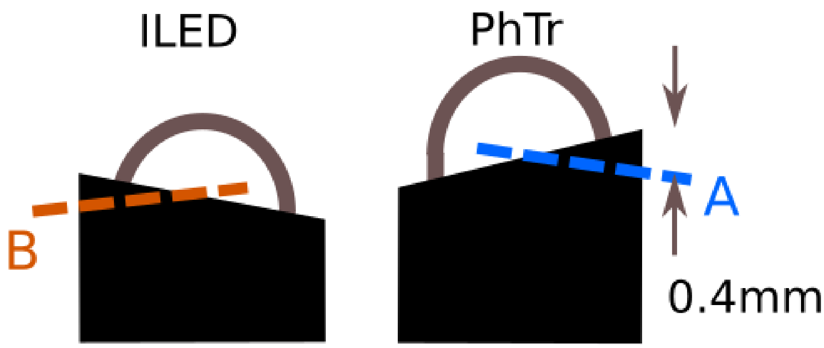


Figure 3-11. black cover cut

Notice:

- There is a limit to how much sensitivity can be increased or decreased due to device variations.
- If you cut too much, it will break. (becoming always responsive)
- Do not cut if the height of the black cover is lower than the others.

Decrease sensitivity: (Reduce exposure of ILED, PhTr, less receive light)

1. Raise the PhTr black cover.
2. If 1 is useless, raise the black cover of ILED.

3-8-1.Main board circuit diagram

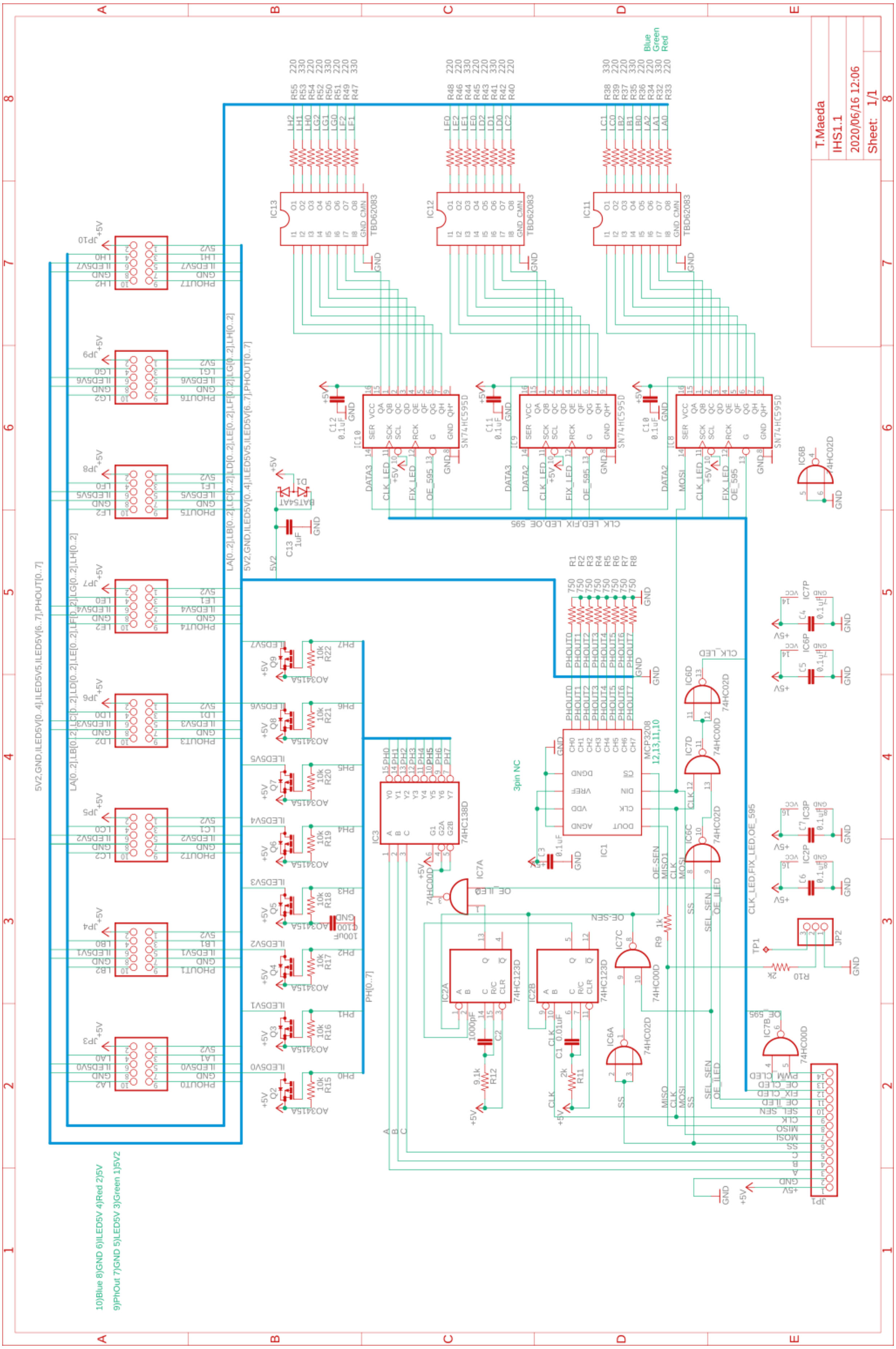


Figure 3-11. Main board circuit diagram

3-8-2.Sensor board circuit diagram

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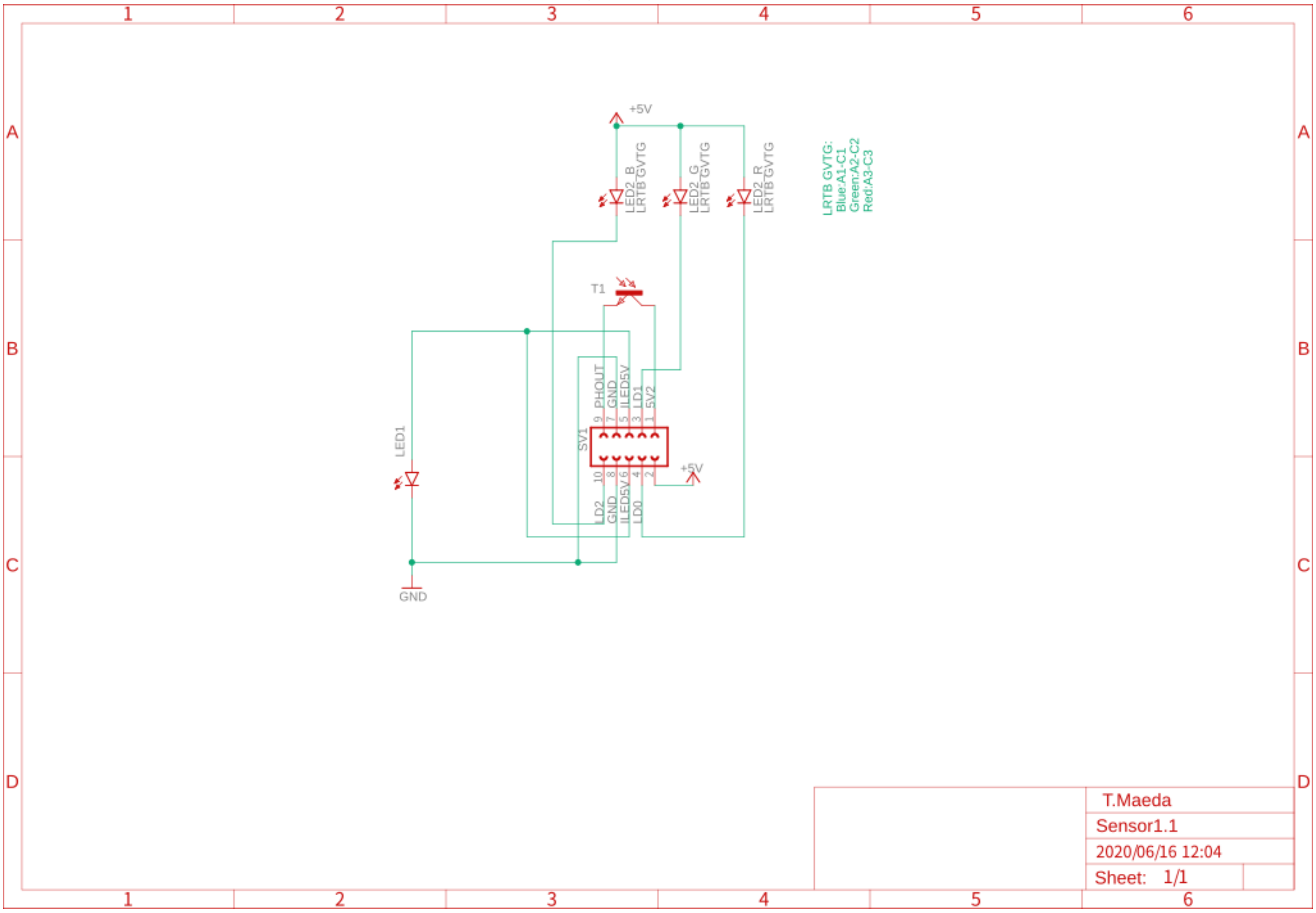


Figure 3-12. Sensor board schematic

3-9. Terminology

word	explanation
CLED	Color LED RGB color LED (sensor board)
ILED	Infrared LED Infrared LED (sensor board)
PhTr	Photo Transistor Phototransistor (sensor substrate) a device that converts light into electrical current,Figure 2-2It converts the current into voltage as well.
X/Y/Z direction	as shown below

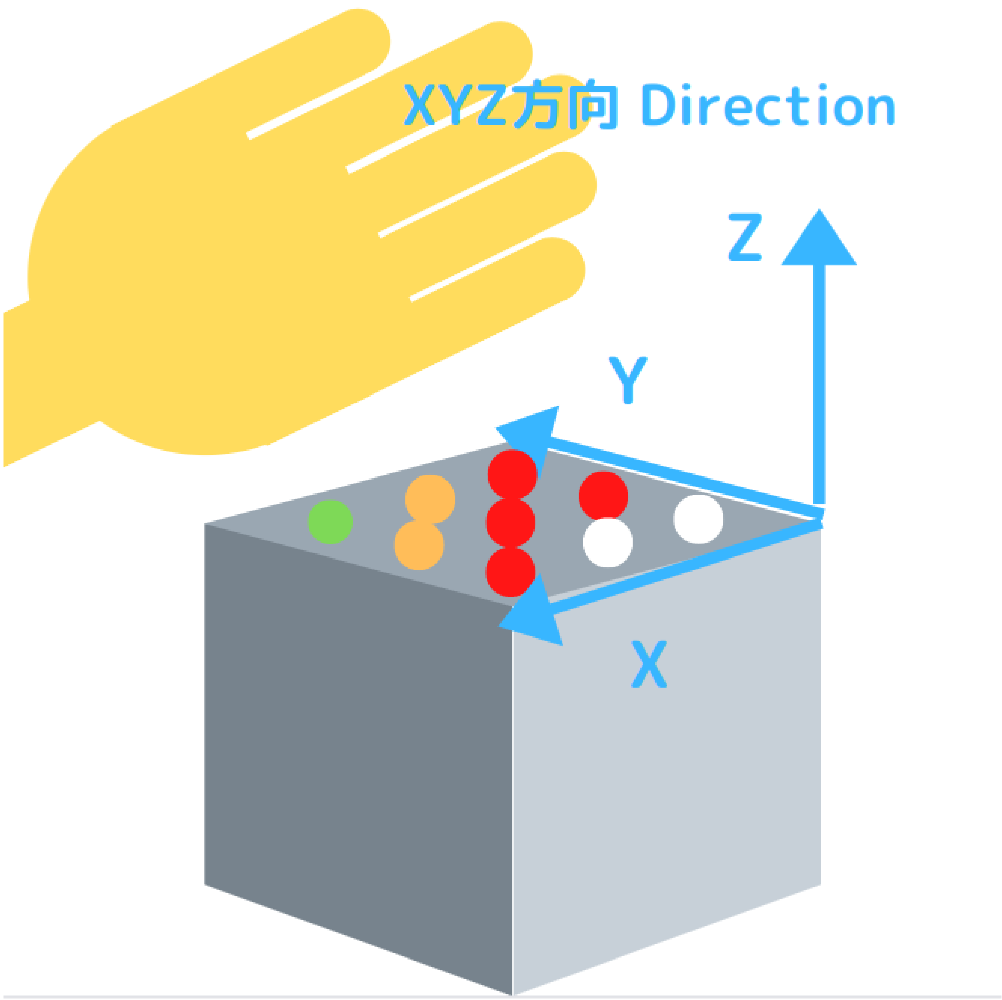


Figure 3-13.XYZ directions

4. Software and interface

4-1.SPI interface setting (AD converter/shift register)

- SPI-MODE:0
- CLOCK：2MHz ※
- **One cycle (time interval between accesses to the same ILED) is 1.2mS or more※**

* To ensure the quality and life of the ILED.

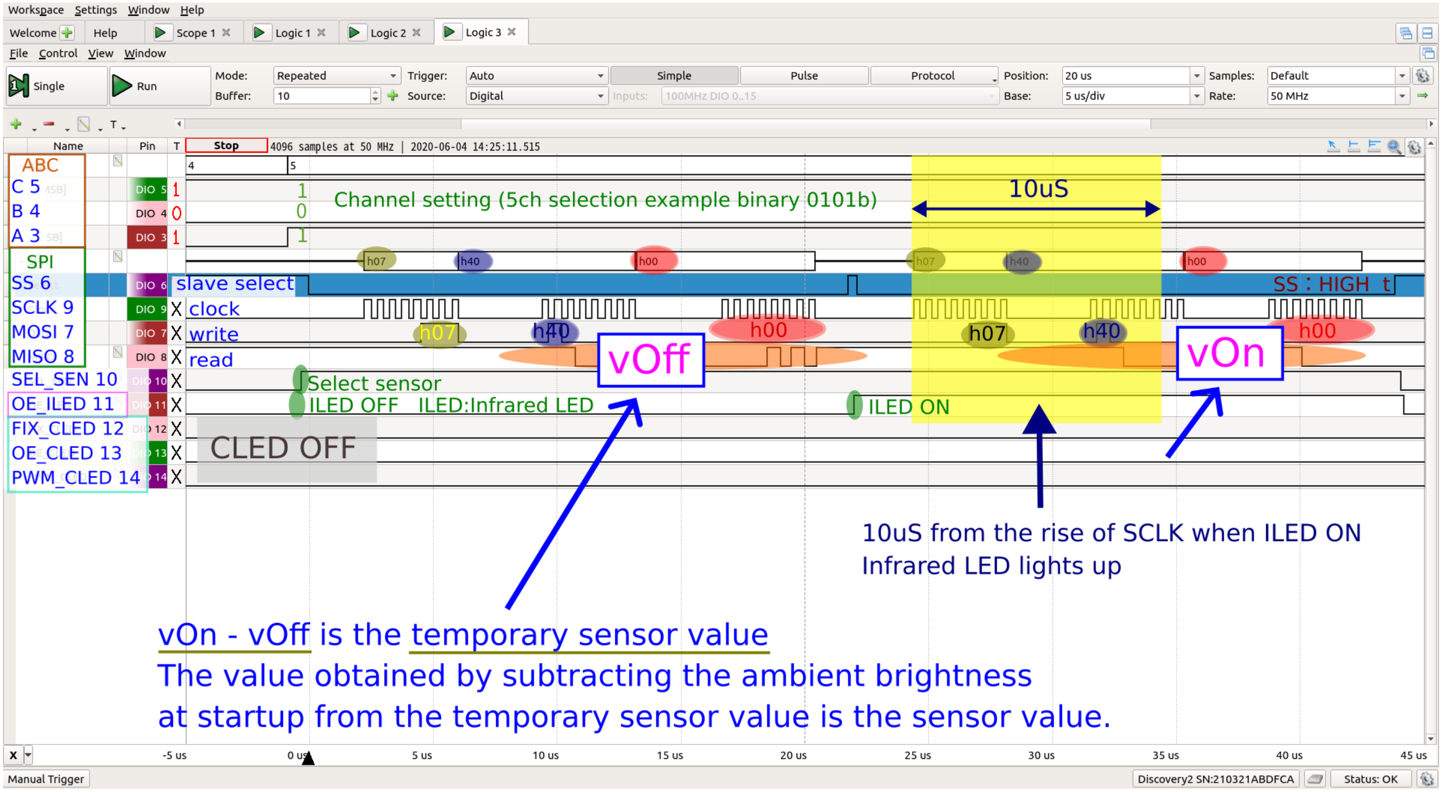
4-2.AD converter reading procedure

1. OE_CLED：LOW
2. A,B,C：　　　　　　Sensor channel setting
3. SEL_SEN: HIGH Select sensor, do not select CLED

4. OE_ILED：LOW　ILED OFF　　　※ ILED: Infrared LED
5. SS　　　：LOW
6. **SPI-read**　AD read value:**vOff**
7. SS　　　：HIGH

8. OE_ILED：HIGH ILED ON
9. SS　　　：LOW
10. **SPI-read**　AD read value:**from**
11. SS　　　：HIGH
12. Temporary sensor value:**fromOn - fromOff**　Save in an array

※　**The value obtained by subtracting the ambient brightness measured at startup from the temporary sensor value is the sensor value.**



4-1. Logic analyzer sensor reading diagram

4-3.Read code of AD converter

8 sensor readings

```
void Sensor::setAd(bool bInit) {            // bInit:add val to adAryInit[]
        for (int col = 0; col < COL_LEN; col++) {// COL_LEN : 8
                setCol(col, bInit);                  // *** sensing ***
        }
        if (!bInit)                                  // *** set CLED ***
                cled.set(val);                       // sensor-data, indicator
}
```

Reading of a single sensor

```
void Sensor::setCol(int col, bool bInit) {
        int ledSta = digitalRead(OE_CLED);
        digitalWrite(OE_CLED, LOW);
        out3bit(abc, col);
        digitalWrite(SEL_SEN, HIGH);
        digitalWrite(OE_ILED, LOW); // ILED-OFF
        int vOff =getAdc(col);                       // *** read ADC ***
        digitalWrite(OE_ILED, HIGH);                 // ILED-ON
        int ofOn =getAdc(col);                       // *** read ADC ***
        digitalWrite(SEL_SEN, LOW);
        digitalWrite(OE_ILED, LOW); // ILED-OFF
        digitalWrite(OE_CLED, ledSta);
        if (bInit)
                adAryInit[col] += vOn - vOff - (vOff >> 2) + (vOn >> 4);
        else
                adAry[col] = noMinus(vOn - vOff - (vOff >> 2) + (vOn >> 4) - adAryInit[col]);
        val[col] = ad2val(adAry[col]);               // adAryInit[col]: Ambient brightness measured at startup
}

unsigned int Sensor::getAdc(int col) {
        digitalWrite(SS, LOW);
        SPI.transfer(6 | (col >> 2));//
        unsigned char r1 = SPI.transfer(col << 6);
        unsigned char r2 = SPI.transfer(0);
        digitalWrite(SS, HIGH);
        return ((r1 & 0x0f) << 8) + r2;
}
```

4-4.CLEDData transfer method

1. SEL_SEN LOW : Select CLED.
2. OE_CLED and PWM_CLED LOW : Turn off the CLED output.
3. Convert the colors of sensor values 1-6 to 3-bit RGB values and transfer them to the shift register. (Table below)
4. When FIX_CLED is HIGH and LOW and one pulse is output, the value is reflected in the shift register.
5. OE_CLED and PWM_CLED HIGH: CLED glows.

Sensor value 1-6: color conversion table

Sensor value 1-6	1	2	3	4	5	6
color	red	yellow	green	light blue	green	purple

Color: RGB value 3bit conversion table

color	Red (R)	Yellow (GR)	Green (G)	Aqua (BG)	Blue (B)	Purple (BR)
BGRvalue 3bit	1 (001)	3 (011)	2 (010)	6 (110)	4 (100)	5 (101)

Convert Sensor sample values 1-6 to Color values

channel	0	1	2	3	4	5	6	7
Sensor value 1-6	1	2	3	4	5	6	1	2
BGRvalue 3bit	1 (001)	3 (011)	2 (010)	6 (110)	4 (100)	5 (101)	1 (001)	3 (011)

Flip color value horizontally

channel	0	1	2	3	4	5	6	7
BGRvalue 3bit	1 (001)	3 (011)	2 (010)	6 (110)	4 (100)	5 (101)	1 (001)	3 (011)
Shift bit **(Flip horizontal)**	<<0	<<3	<<6	<<9	<<12	<<15	<<18	<<21
After Shift decimal	3 (011) 1 (001) 5 (101) 4 (100) 6 (110) 2 (010) 3 (011) 1 (001)							
After Shift 24bit binary	011 001 101 100 110 010 011 001							
Serial out 24bit	0110 0110 1100 1100 1001 1001							

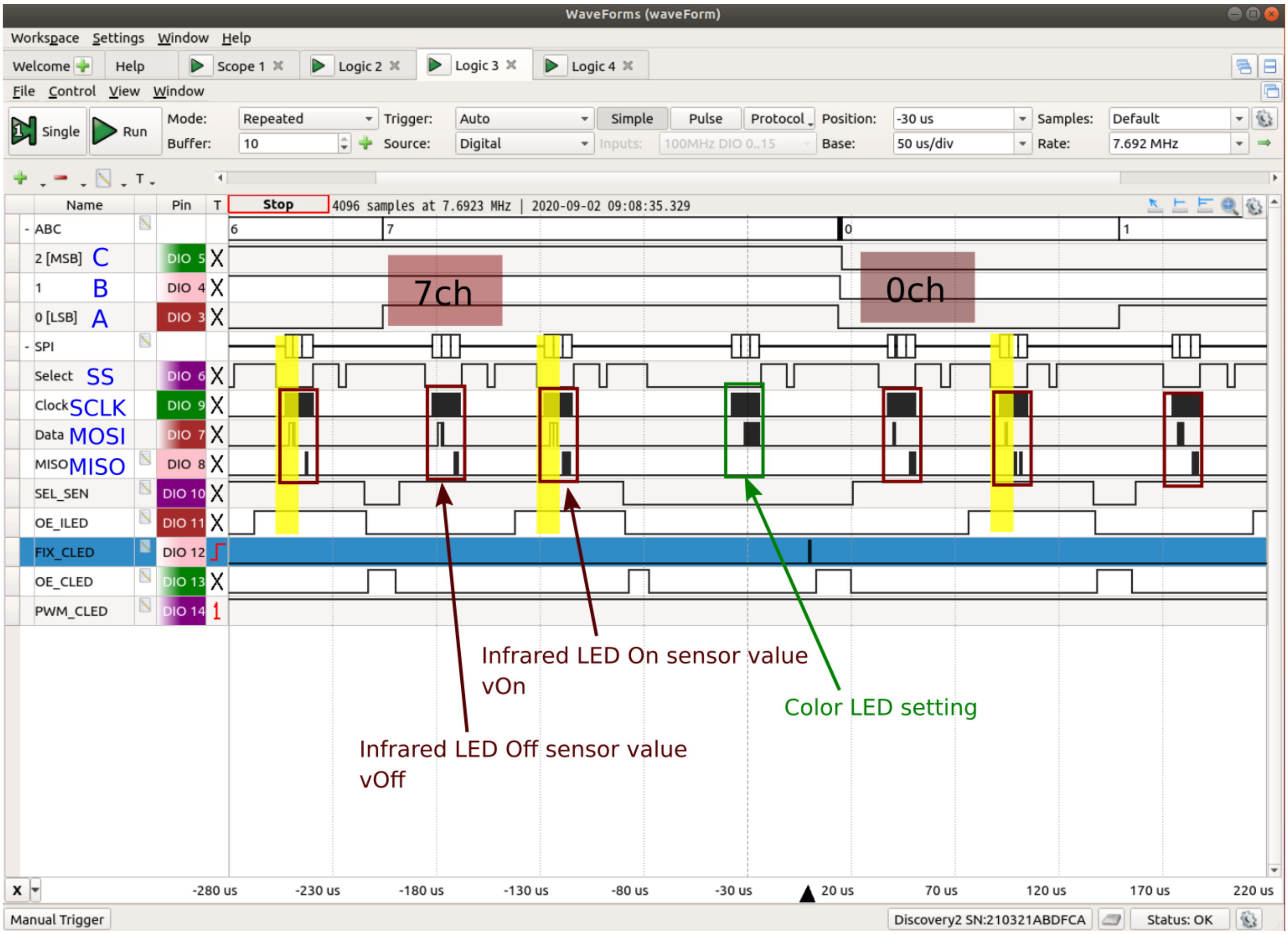


Figure 4-2. Logic analyzer CLED write

4-5.CLED code

```
void CLED::set(byte* pAry, bool isInd) {                  // 1-12[8]:{7, 3,..}
    if (isInd) {                                          // *** blink indicator ***
        int indiCnt = INDI_CNT << ((inOn) ? 0 : 2);
        if (++inCnt == indiCnt) {
            inCnt = 0;
            inOn = !inOn;
        }
    }
// ****************************
    unsigned long val24 = 0;
    bool isCledOn = false;
    for (int col = 0; col < COL_LEN; col++) {             // LED number is opposit direction
        isCledOn |= (pAry[col] > 0);
        bool indOn = isInd && inOn && (col == COL_LEN - 1) && (!isCledOn);    // indicator
        byte val1_6 = IndianOn ? 6 : array[col];
        val24 += (unsigned long)color[val1_6] << col * 3;

        val1_6: Sensor value: 1 red to 6 red purple
        color[val1_6] : Sensor value → BGR conversion value
        val24: Color value, left-right flip, 24-bit value

    }
    digitalWrite(SEL_SEN, LOW);
    digitalWrite(OE_CLED, LOW);
    digitalWrite(SS, LOW);
    for (int b = 2; b>=0; b--) {
        SPI.transfer((val24 >> b * COL_LEN) & 0xff);      // 8-bit by SPI
    }                                                     // write to shift register
    digitalWrite(FIX_CLED, HIGH);
    digitalWrite(FIX_CLED, LOW);                          // save the written value
    digitalWrite(SS, HIGH);
    digitalWrite(OE_CLED, HIGH);                          // Color LED on (with PWM)
}
```

5. Parallel connection (cube type)

5-1. Note

- Put the poly switch 500mA into the 5V power supply as shown in the circuit diagram. (Because the inrush current of the capacitor is large and the microcomputer may not start.)
- Remote controls (for air conditioners, home appliances, etc.) in the vicinity may not work. In that case, move the location or change the orientation of the sensor.

5-2. Preparation

- Set only one JP2 to single and the rest to multiple. (JP2 pinout)
- Board selection is SS: LOW, SPI communication only with the selected board.
- Pins other than the SS pin (6pin) are shorted as shown in the circuit diagram.
- Set the scan time to 800uS or more per substrate and 100uS or more per channel.

5-3. Circuit diagram

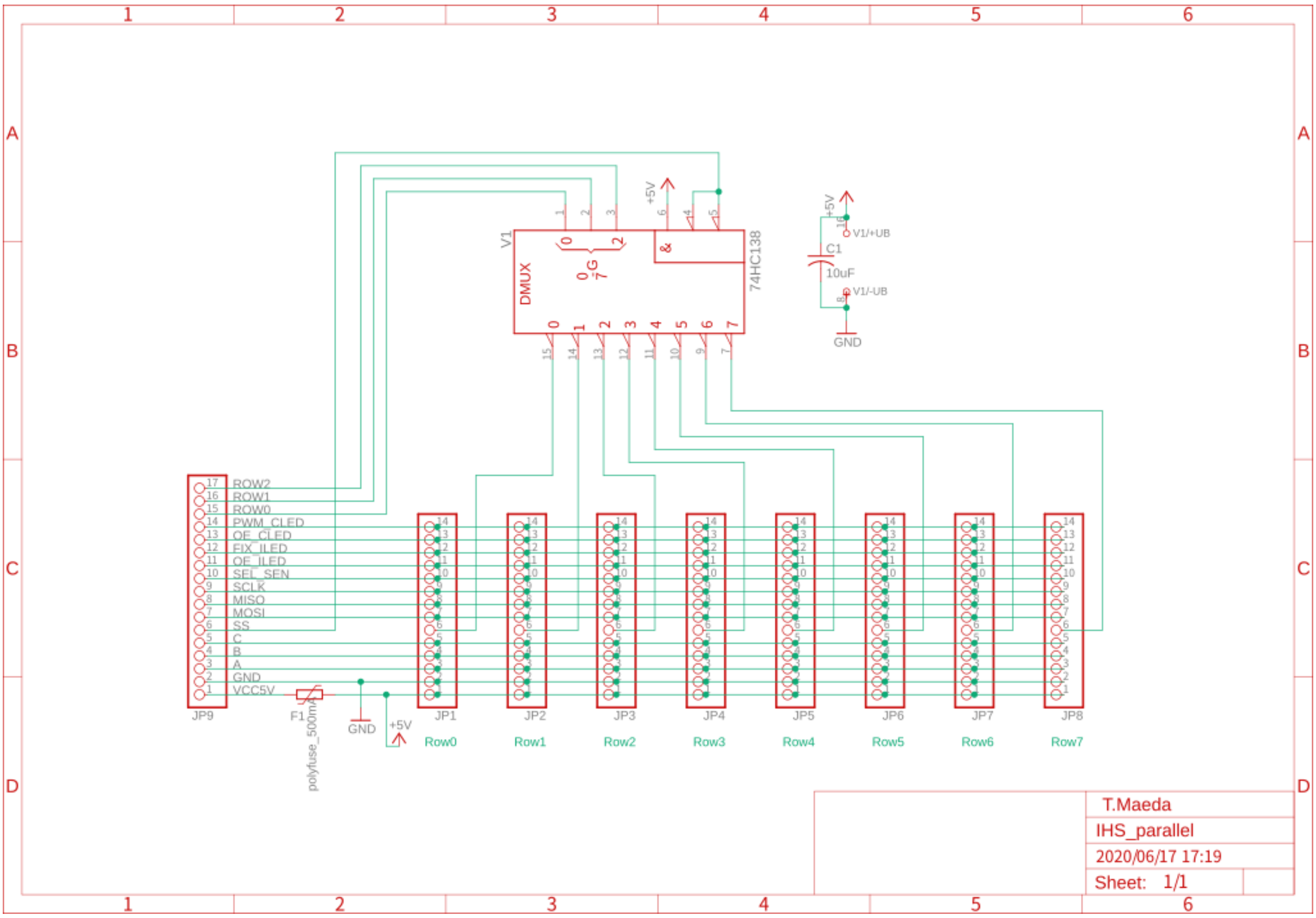


Figure 5-1. Circuit example when 8 devices are connected in parallel

5-4. Application example

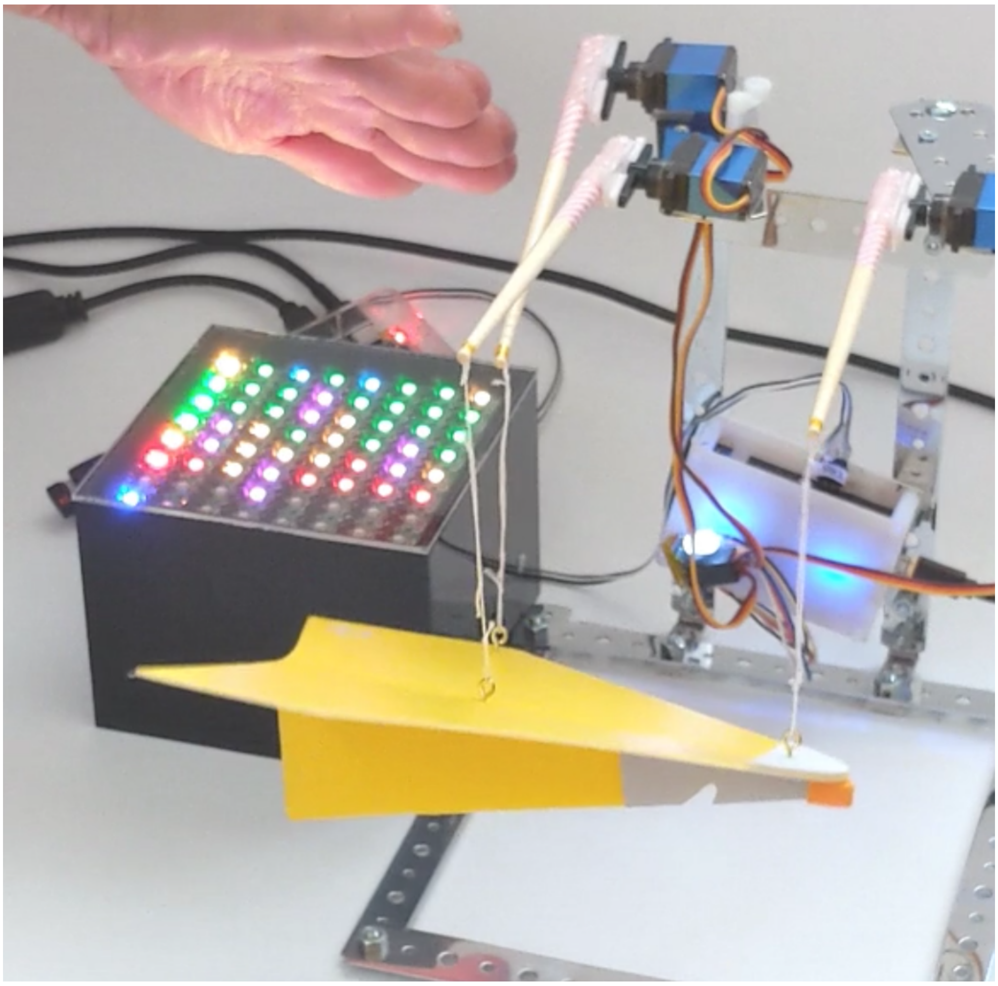


Figure 5-2. Example of paper airplane control with cubes (8 in parallel)

revision

to see	date	changes
1.20	2023/08/12	English version first edition